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Computational models in systemic design

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Computational Models of Complexity to Design for Sustainability

Questions and opportunities

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Sustainability and social systems

- Take a commonly known sustainability challenge, such as plastic waste
- The first inclination is to deal with the waste directly, e.g. by organising beach clean ups
- The first design thought leads to rethinking the products made of plastic, such as packaging.
- Quickly designers dealing with this issue see the need to take into account human systems connected to plastic, such as a local community, the global plastic supply chains, or the worldwide network of additive manufacturing.
- These are all examples of complex social systems.



Source: Stefan van der Heijden, 2018.

100% reusable, recyclable or compostable plastic packaging by 2025

FOLLOW THEIR LEAD



Source: New Plastics Economy, Ellen MacArthur Foundation, 2018.

How does design
approach complexity in
sustainability?

Complexity and sustainability in design

Systemic design

“Systemic design is distinguished from service or experience design in terms of scale, **social complexity** and integration. (...) By integrating systems thinking and its methods, systemic design brings human-centered design to **complex, multi-stakeholder service systems** as those found in industrial networks, transportation, medicine and healthcare.”

Transition design:

“A new, design-led approach should enable stakeholders to arrive at a shared definition of the problem and an **understanding of its complexities and interdependencies**”

Systemic design - Giga-mapping



€16.78 discount

€19,90 regular

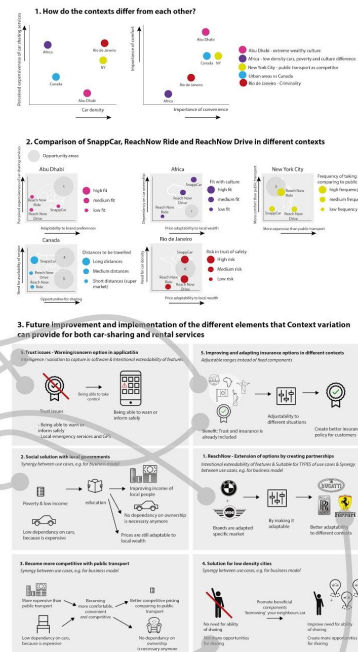
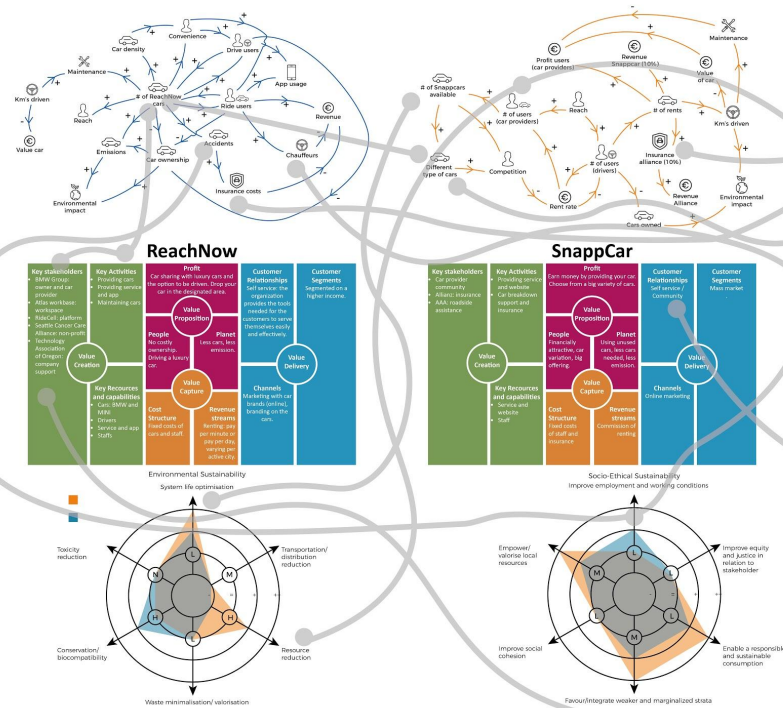
€41.39 3 hours rate



€26,98 2001 Citroën

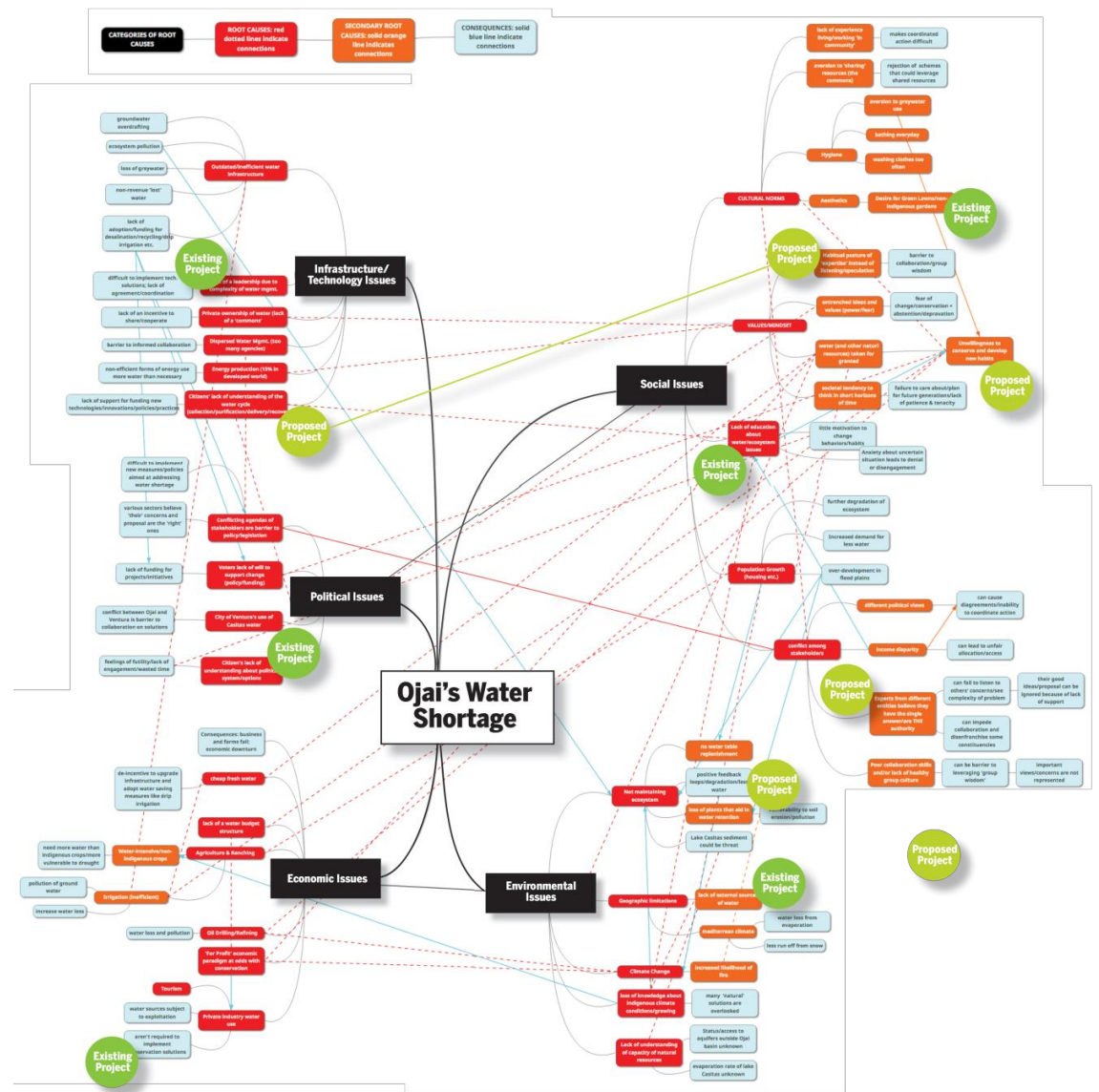
€33.32 2002 MINI

€36.54 1997 BMW

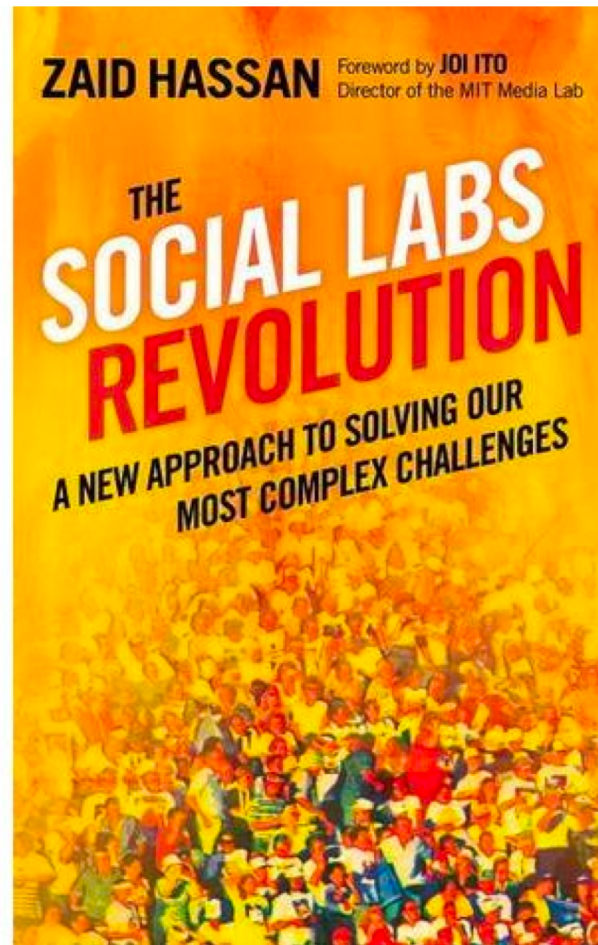


Source: B. van Zwet, C. Mui, J. Janbroers, M. Terranea, S. Botterweck, 2018 (student project)

Source: T. Irwin, 2018, The Emerging Transition Design Approach



Systemic design – participatory design and co-creation



Transition design – future visioning

What aspect of the problem does your snapshot address? print headline below

**NEIGHBORHOOD SAFETY, POLICE AGGRESSION
LACK OF STRONG COMMUNITY**

Describe the ways in which societal and cultural, assumptions, beliefs and norms have changed in 2050. How are they different from the beliefs and assumptions that underpin the problem now?

IN 2050, CRIME IS SEEN AS A RESPONSIBILITY OF EVERY COMMUNITY TO RESOLVE, AND A FAILURE TO SUPPORT THOSE CITIZENS WHO TURN TO CRIME. THE COMMUNITY TAKES RESPONSIBILITY TO JUDGE THE ACCUSED AND TAKE CHARGE OF THEIR REHABILITATION IN ORDER TO SUCCESSFULLY REJOIN SOCIETY. THE FOCUS HAS SHIFTED FROM PUNISHMENT TO REHABILITATION AND ATTAINMENT IN ORDER TO REGAIN DIGNITY AND RESPECT. ULTIMATELY, TO BE ABLE TO LIVE AND CONTRIBUTE MEANINGFULLY.

**Snapshots
of Lifestyles
in 2050**

1. A WOMAN AND POLICE ARE TAKEN AWAY IN A LOCAL NEIGHBORHOOD

2. HE IS ARRESTED BY THE LOCAL NEIGHBORHOOD SECURITY FORCE AND TAKEN TO THE REHABILITATION CENTER

3. IN THE REHABILITATION CENTER HE MEETS OTHERS WHO ARE ALSO IN THE CENTER. THEY ARE ALL THERE TO REHABILITATE THEMSELVES AND TO HELP OTHERS.

4. WHILE HE AND HIS VICTIM UNDERGO REHABILITATION, HE MEETS AT THE REHABILITATION CENTER, WHERE HE IS GIVEN MEDICAL CARE, EDUCATION, AND LIVES IN THE COMMUNITY CENTER IN WHICH THE REHABILITATION CENTER IS HOSTED. HE IS ALSO GIVEN VARIOUS ACTIVITIES IN THE CENTER, INCLUDING GARDENING AND GARDENING.

5. AFTER A FEW WEEKS HE MEETS WITH THE VICTIM TO RE-ADDRESS AND RESTITUTION IS INSTANTLY MADE UPON

6. HIS SENTENCE IS COMPLETED OF COMMUNITY SERVICE AND HE MEETS TO HELP HIS VICTIM HOLD A VEGETABLE GARDEN

7. AFTER HE SERVES HIS SENTENCE, HE IS GIVEN THE OPTION OF JOINING THE COMMUNITY. HE IS RESPECTED FOR HAVING PAID HIS DEBT AND BEGINS TO WORK 'AT RISK' YOUTH IN THE COMMUNITY.

GROUP NAME

FRIENDSHIP RESIDENTS

SNAPSHOT PROFILE

At what level of scale is your snapshot situated?
(The household, neighborhood, city or region)

THE NEIGHBORHOOD

What fears/concerns/hopes/aspirations does it address?

LACK OF COMMUNITY INVOLVEMENT, OVERALL LACK OF SAFETY IN THE NEIGHBORHOOD, MORE "EYES ON STREET" POLICING THAT INVOLVES THE LOCAL COMMUNITY, SOME OF THE ROOT CAUSES OF CRIME ARE BEING ADDRESSED (DRUG ADDICTION, LACK OF COMMUNITY ROLE MODELS, INABILITY TO MAKE A LIVING/UNEMPLOYMENT)

What basic needs (according to Maslow) are met by this snapshot from the future?

PROTECTION, UNDERSTANDING, PARTICIPATION, SUBSISTENCE, CREATION, IDENTITY, FREEDOM.

Transition Design Tools: Irwin & Kossloff, Carnegie Mellon University 2017

Source: T. Irwin, 2018, The Emerging Transition Design Approach

How do complexity
scientists approach
social systems?

Computational models of social systems in sustainability - examples

Systems of differential equations

Slow Response of Societies to New Problems: Causes and Costs

Marten Scheffer,^{1*} Frances Westley,² and William Brock³

Agent-based models

Agent-Based Modeling and Industrial Ecology

*Robert L. Axtell, Clinton J. Andrews,
and Mitchell J. Small*

System dynamics

Navigating towards sustainable development: A system dynamics approach

Peder Hjorth^{a,1}, Ali Bagheri^{a,b,*}

Networks

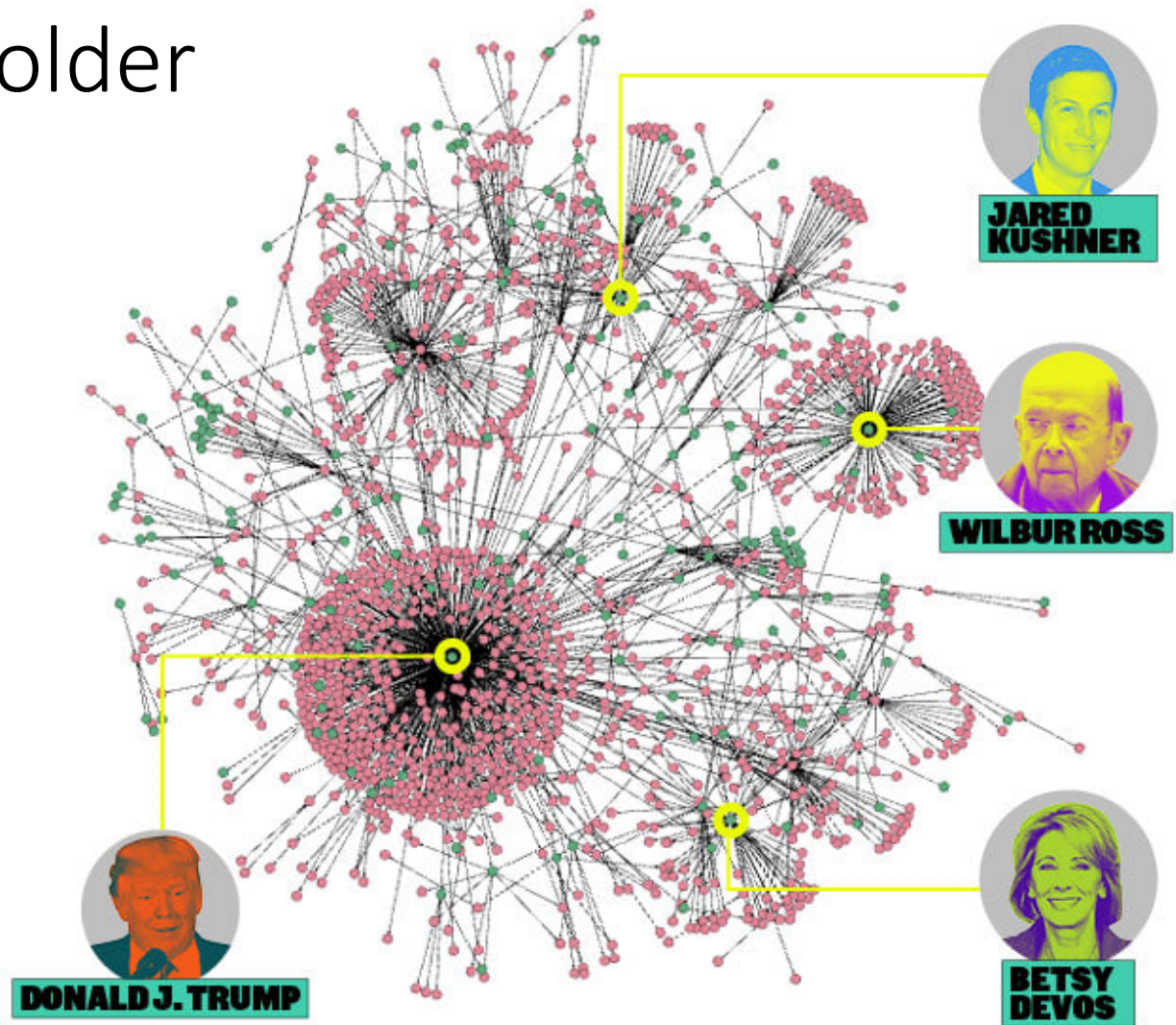
Disentangling intangible social–ecological systems

Örjan Bodin^{a,b,*}, Maria Tengö^{a,b}

Are there opportunities
to apply these
techniques to design?

Prioritise stakeholder engagement

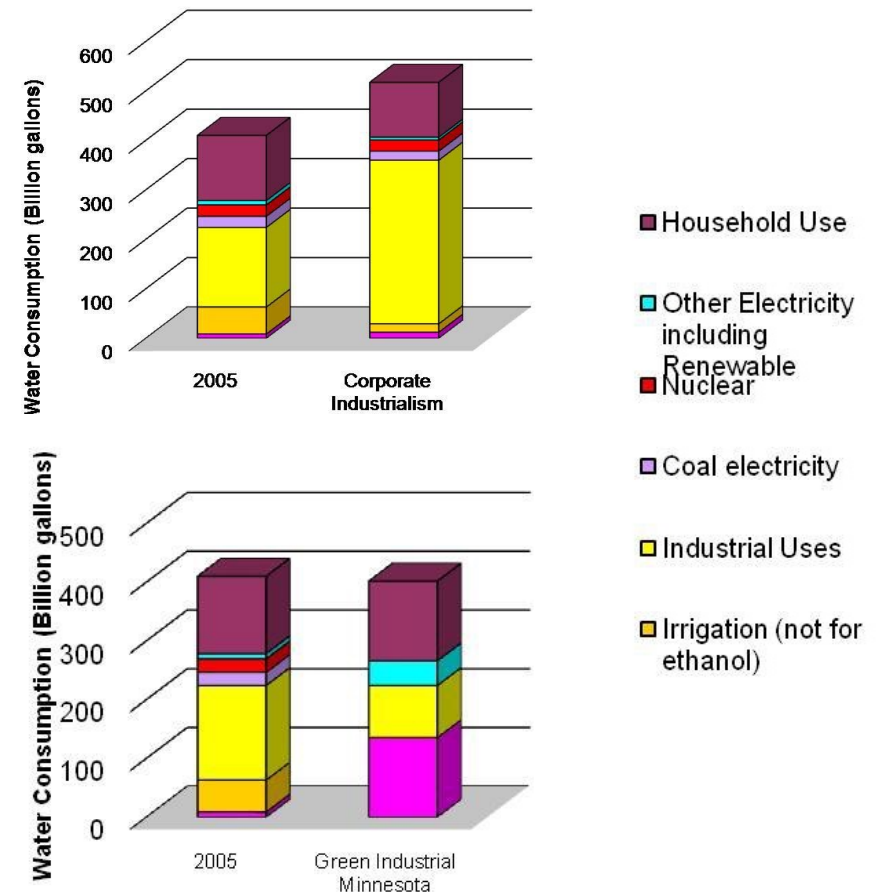
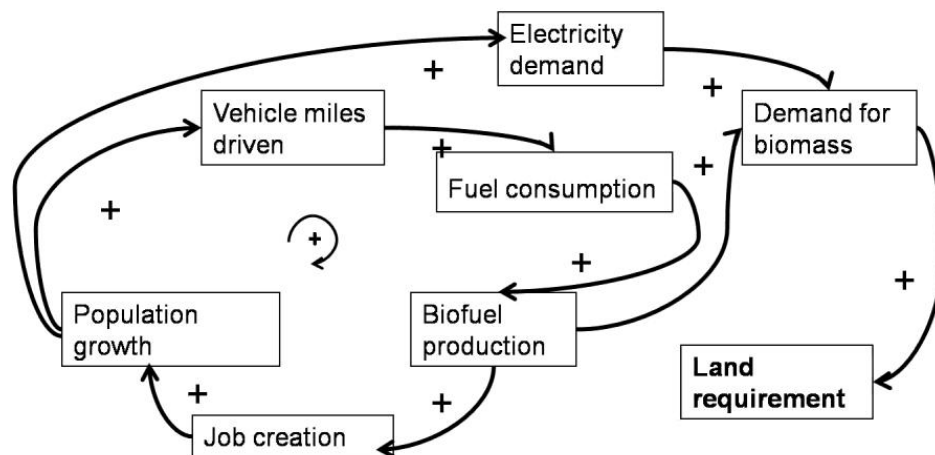
- Network science
- Data scraping and crowd-sourced data



Source: Templon, J., Cormier, A., Campbell, A., Singer-Vine, J., BuzzFeed.

Prioritise interventions

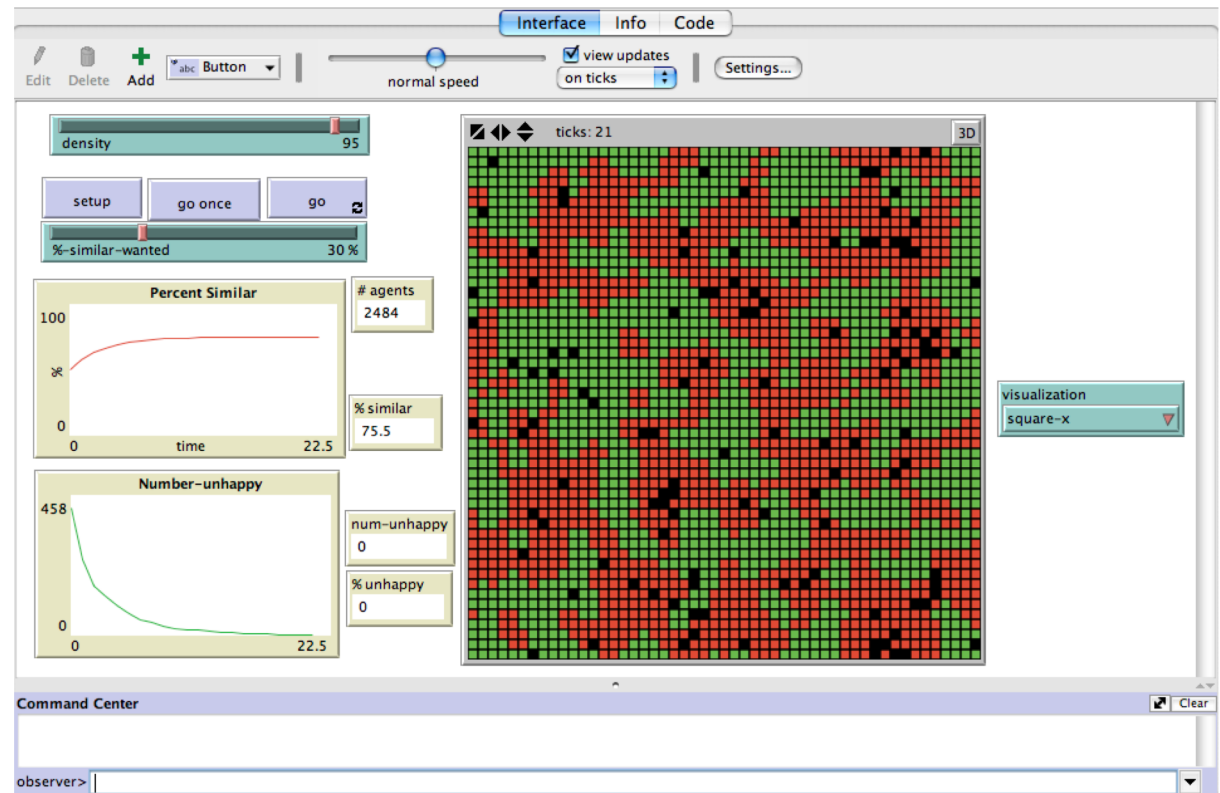
- System dynamics
- Participatory modelling



Source: Schmitt Olabisi, L., et al., 2010, Using Scenario Visioning and Participatory System Dynamics Modeling to Investigate the Future

Simulate stakeholder / user behaviour

- Agent-based model
- Purely theoretical



Source: Schelling, T., 1978, Micromotives and Macrobehavior; Wilensky, U., 1997, NetLogo Segregation model.

Opportunities for design - examples

Stakeholder analysis

- Prioritise stakeholder engagement
- Simulate stakeholder/user behavior

Future visions

- Simulate sustainable business models
- Simulate future supply chains and industries

Design choices

- Prioritise potential interventions

What may have prevented
computational modelling in
design for sustainability to date?

1) Can humans be modelled?

Recommendations:

- Acknowledge assumptions and values
- Leverage data from online tools
- Address ethics issues

2) Are design and modelling compatible?

Recommendations:

- Leverage designers' intuition as a starting point
- Develop designer and stakeholder-friendly interfaces
- Involve stakeholders in the development of the model

3) Can you model with limited data?

Recommendations:

- Don't underestimate data available
- Work with plausible models and multiple scenarios
- Develop models in an iterative way

Take aways

- Make your assumptions explicit and consider ethics questions
- Leverage data from online tools and big data analysis methods
- Develop simulation interfaces for designers and stakeholders
- Leverage stakeholders' intuition
- Adopt an iterative approach to model building

Next steps: demonstrator case studies

Case requirements

- Social complexity, sustainability objectives, designers involved
- Curiosity, willingness to experiment
- Access to data

Case 1: Designing a marketplace for material reuse in the **built environment**

- Modelling the current and future built environment ecosystems
- Prioritizing stakeholder engagement

Case 2: Redesigning the **psychiatry** system

- Identifying sources of stagnation in current system
- Prioritizing stakeholder engagement

Thank you!